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ADDRESS

OF

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Of the leaders in Natural Science, the guides and teachers of some of us now becoming gray, who have in the past year been stricken by death from the roll of workers here, and have entered into the unseen world, two rise before me with special vividness on the present occasion :—Lyell, our greatest geological thinker, the classifier of the Tertiary rocks, the summer up of the evidence on the antiquity of man ; but above all the founder of that school of geology which explains the past changes of our globe by those at present in progress ; and Logan, the careful and acute stratigraphist, the explorer and establisher of the Laurentian system, and the first to announce the presence of fossil remains in those most ancient rocks. What these men did and what dying they left undone, alike invite us to the consideration of the present standpoint of Geological science, the results it has achieved and the objects yet to be attained ; and I propose accordingly to select a small portion of this vast field and to offer to you a few thoughts in relation to it, rather desultory and suggestive however, than in any respect final. I shall therefore ask your attention for a short time to the question—"What do we know of the origin and history of life on our planet?"

This great question, confessedly accompanied with many difficul-

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ties and still waiting for its full solution, has points of intense interest both for the Geologist and the Biologist. In treating of it here, it will be well, however meagre the result, to divest it of merely speculative views, and to present as far as possible the actual facts in our possession, and the conclusions to which they seem to point.

"If," says that greatest of uniformitarian geologists, who has so recently passed away, "the past duration of the earth be finite, then the aggregate of geological epochs, however numerous, must constitute a mere moment of the past, a mere infinitesimal portion of eternity." Yet to our limited vision, the origin of life fades away in the almost illimitable depths of past time, and we are ready to despair of ever reaching, by any process of discovery, to its first steps of progress. At what time did life begin? In what form did dead matter first assume or receive those mysterious functions of growth, reproduction and sensation? Only when we picture to ourselves an absolutely lifeless world, destitute of any germ of life or organization, can we realize the magnitude of these questions, and perceive how necessary it is to limit their scope if we would hope for any satisfactory answer.

I shall here dismiss altogether that form in which these questions present themselves to the biologist, when he experiments as to the evolution of living forms from dead liquids or solids — an unsolved problem of spontaneous generation which might alone occupy the whole time of this Section. Nor shall I enter on the vast field of discussion as to modern animals and plants opened up by Darwin and others. I shall confine myself altogether to that historical or palæontological aspect in which life presents itself when we study the fossil remains entombed in the sediments of the earth's crust, and which will enable me at least to show why some students of fossils hesitate to give in their adhesion to any of the current notions as to the origin of species. I may also explain that I shall avoid, as far as possible, the use of the term evolution, as this has recently been employed in so many senses as to have become nearly useless for any scientific purpose, and that when I speak of creation of species, the term is to be understood not in the arbitrary sense forced on it by some modern writers, but as indicating the continuous introduction of new forms of life under definite laws, but by a power not emanating from within themselves, nor from the inanimate nature surrounding them.

If we were to follow the guidance of those curious analogies which present themselves when we consider the growth of the individual plant or animal from the spore or the ovum, and the development of vegetable and animal life in geological time—analogies which, however, it must be borne in mind can have no scientific value whatever, inasmuch as that similarity of conditions which can alone give force to reasoning from analogy in matters of science, is wholly wanting—we should expect to find in the oldest rocks embryonic forms alone, but of course embryonic forms suited to exist and reproduce themselves independently.

I need not say to palæontologists that this is not what we actually find in the primordial rocks. I need but to remind them of the early and remarkable development of such forms as the Trilobites, the Lingulidæ and the Pteropods, all of them highly complex and specialized types, and remote from the embryonic stages of the groups to which they severally belong. In the case of the Trilobites, I need but refer to the beautiful symmetry of their parts both transversely and longitudinally, their division into distinct regions, the complexity of their muscular and nervous systems, their highly complex visual organs, the superficial ornamentation and microscopic structure of their crusts, their advanced position among Crustaceans, indicated by their strong affinities with the Isopods. All these characters give them an aspect far from embryonic, while, as Barrande has pointed out, this advanced position of the group has its significance greatly strengthened by the fact that in early primordial times we have to deal not with one species but with a vast and highly differentiated group, embracing forms of many and varied subordinate types. As we shall see, these and other early animals may be regarded as of generalized types but not as embryonic. Here then meets us at the outset the fact that in as far as the great groups of annulose and molluscous animals are concerned, we can trace these back no further than in a period in which they appear already highly advanced, much specialized and represented by many diverse forms. Either therefore these great groups came in on this high initial plane, or we have scarcely reached half way back in the life history of our planet.

We have here, however, by this one consideration attained at once to two great and dominant laws regulating the history of life. First, the law of continuity, whereby new forms come in

successively, throughout geological time, though as we shall see with periods of greater and less frequency. Secondly, the law of specialization of types, whereby generalized forms are succeeded by those more special, and this probably connected with the growing specialization of the inorganic world. It is this second law which causes the parallelism between the history of successive species and that of the embryo.

But there are great masses of strata known as Lower Cambrian, Huronian, Laurentian, which have made as yet few revelations as to the life which may have existed at the time of their deposition. In these rocks we know the problematical *Aspidella* of Billings from Newfoundland, the worm-burrows or Scolithus-like objects which occur in the Pre-silurian rocks of Madoc, the *Eozoon Bavaricum* of Gumbel, and the *Eozoon Canadense*, first made known by Logan, in the Laurentian of Canada. The first of these names represents a creature that may have been a mollusk, allied to Patella, or some obscure form of crustacean. The cylindrical holes called worm-burrows, are of course quite uncertain in their reference. They may represent marine worms in no respect different from those now swarming on our shores, or sponges, or corals, or sea-weeds. In any case they afford little help in explaining the teeming life of the primordial seas, and we can only hope that the vast thickness of sediments which has afforded these few traces of life may prove more fertile in the future. One slender beam of light in the darkness is, however, afforded by the *Eozoon Bavaricum* of Gumbel. If truly a fossil, this creature is closely connected with the still older *Eozoon* of the Laurentian. It therefore points backward to what is to us the dawn of life, but has no close link of connection with the succeeding fauna. On the other hand *Aspidella* and *Scolithus* may be held, if obscurely, to point forward. Thus the Huronian and early Cambrian become a period of transition from the Protozoa of the Laurentian to the higher marine life that succeeds—a passage to be more fully explained perhaps, and its great gaps filled by future discoveries; but which may, as in some later periods, be complicated with a contemporaneous transition from oceanic to shallow-water conditions in the localities open to exploration.

It will be observed that I take for granted the animal nature of Eozoon. If we reject this, we stand face to face with the bare, bald mystery of the abrupt manifestation of the Primordial fauna,

without even so much of preparation as may be supposed to arise from the previous appearance of Protozoa.

How then stand the facts as to the Proto-foraminifer? In answering this question, we should, I think, endeavor to divest ourselves of certain prejudices, and to give due weight to some probabilities and analogies which may in one way or another sway our opinion.

First, we must be prepared to find that those old crystalline rocks which we call Laurentian, have no real affinity with intrusive granites and other igneous masses, but are most nearly allied to modern sedimentary deposits. That the original chemical character of some of these ancient sediments may have differed to some extent from that of more modern sediments I do not doubt. Yet it is true that the more common of them, as the gneisses, diorites and mica-schists, consist of precisely the same elements which now appear in modern clays and sands, and that where local alteration has affected more modern rocks, we see these passing by insensible gradations into similar metamorphic beds. Farther when the old crystalline rocks are subjected to subaerial disintegration, they resolve themselves again into the most common sedimentary materials.

Another consideration here is the unequal manner in which sediments become altered according to their composition, and to the extent to which they are permeable by heated waters and vapors. For this reason, contiguous beds of rock will often be seen to differ very much in the degree of their alteration. Farther, some beds, and more especially limestones, continue to retain traces of organic structure long after these have perished from neighboring beds of different chemical composition. More especially when, in limestone, the cavities and pores of the fossils have been penetrated with other mineral matter, it would appear that nothing short of actual fusion will serve to obliterate them. Again, microscopic structures are often well preserved when the external forms have been lost, or are completely inseparable from the matrix, and in the present state of microscopical science there is little danger that in such specimens any experienced microscopist will fail to perceive the difference between organic and crystalline structures.

Having freed ourselves from misconceptions of these kinds, we may next turn to certain presumptions established by the consti-

tution of the Laurentian rocks, and the minerals contained in them.

The limestones of the Laurentian system are of great thickness and of vast geographical extent. Sir W. E. Logan has traced and measured three principal bands of these limestones, ranging in thickness from 60 to 1,500 feet, and traceable continuously in one district of Canada for more than one hundred miles, while their actual horizontal area must be enormously greater than this distance would indicate. These limestones are also associated with gneissose and schistose beds, exactly in the same way in which Palæozoic limestones are associated with sandstones and shales; and some of them are ordinary limestones, while others are more or less dolomitic, in which also they resemble the palæozoic limestones. Every geologist knows that the beds which in the succeeding geological periods are the representatives of these Laurentian limestones, are not only fossiliferous, but largely composed of the dèbris of oceanic organisms, and that it is to the purer and more crystalline beds that this statement most fully applies. May we not reasonably infer that the great Laurentian limestones are of similar origin.

One feature of these beds which has sometimes received a very different interpretation, I would here place in this connection. It is the association of Hydrous Silicates, and especially of Serpentine and Loganite, with the limestones, an association not universal but by no means uncommon in the Laurentian, and which may now be affirmed to occur throughout the whole series of marine organic limestones, up to the chalky foraminiferal mud now accumulating in the depths of the ocean. It is true that the silicates found in different formations differ somewhat in composition, but Dr. Sterry Hunt has shown that the Serpentines, Jollite, Loganite and the various Glauconites constitute a single series, whose members graduate into each other, and some of the modern Glauconites are not essentially distinct from the most ancient Serpentine.

This association is not accidental. It arises in the first place from the facility afforded for the combination of Silica with bases, arising from the presence of organic matter in the sea-bottom, and secondly from the abundance of soluble Silica in the hard parts of Diatoms, Radiolarians and Sponges, while these form the chief food of animals building their own skeletons of Carbonate of Lime, and consequently having no need of Silica. In this

point of view the Hydrous Silicates may be regarded as a sort of coprolitic matter, rejected by Foraminifera and other humble marine animals having calcareous skeletons. I hold, therefore, that the association of Serpentine and Loganite with the Laurentian limestones affords an additional reason for regarding them as organic, while it also explains the favorable conditions in which Foraminifera exist for the permanent preservation of the structures of their tests.

But again, there are vast quantities of Carbon in these limestones and the associated beds. The quantity of carbon in some large regions of the Lower Laurentian in Canada, is, as I have elsewhere shown, comparable with that in similar thicknesses of the Carboniferous system. But what geologist refers the carbon of the Palæozoic rocks to any other than an organic origin. True it is that this carbon of the Laurentian is in the state of graphite and destitute of organic structure; but this applies to similar material in other altered rocks, for example, to the graphitic shales of the Silurian of Eastern Canada and to the coal of Rhode Island.

Lastly, ought we not to attach some value to that generalization of Dr. Sterry Hunt, which affirms that the grand agent in the reduction and solution of the Peroxide of Iron has been organic matter. In this case what incalculable quantities of perished carbonaceous matter must be represented by the great beds of Magnetite in the Laurentian.

If, then, it is not unreasonable to believe that the Laurentian limestones may be of organic origin, the next question that occurs relates to the state of preservation in which the remains of such supposed organisms may occur. It would be conceivable that the process of crystalline rearrangement of particles might have proceeded so far as entirely to obliterate all traces of organic form or structure; but judging from other cases of altered limestones, this would be scarcely likely. In such limestones it is true, the fossils are often so obscure as to make little appearance on a fresh fracture of the stone, but they may present themselves distinctly on the weathered surfaces, in consequence of some difference either in resisting power or hardness, between the fossil and the matrix. In some cases also they can readily be developed by the action of an acid, and still more frequently their microscopic textures remain when the external forms are entirely concealed. There are

few crystalline marbles, once fossiliferous, that do not exhibit indications of their true nature in one or other of these ways.

It was precisely in the ways above indicated that *Eozoon Canadense* was first brought to light. The casts of its flattened chambers filled with Serpentine, Loganite or Pyroxene, project from the weathered surfaces of the Laurentian limestones, exactly as silicified Stromatoporæ do in the Silurian. Such specimens, collected by the explorers of the Canadian Survey, first gave the idea that there were fossils in these ancient rocks, and the microscope soon confirmed the indications afforded by external form, and demonstrated the place of the organism in the animal kingdom.

Into the description of the forms and structures of Eozoon it would be out of place to enter here. The details of these may be found in publications specially devoted to its description. I would merely insist on the entire conformity of the microscopic structures as I have myself examined and described them, and as they have been farther scrutinized by Dr. Carpenter and others best fitted to judge, with those of the calcareous tests of Foraminifera, and especially of the Nummuline group, and on the harmony of these structures with what the general considerations already referred to would lead us to expect.

It is, however, appropriate to our present subject, to inquire as to the position of Eozoon in the scale of animal existence, and its possible relations to preceding or succeeding types of life. With reference to these questions, it is obvious that we can predicate nothing as to the relation of our proto-foraminifers to the varied life of the Primordial or to any other group of animals than its own. We do not know that Eozoon was the only animal of its time. It may be merely a creature characteristic, like some of its successors, of certain habitats in the deep sea. Foraminifera have existed throughout the whole of geological time; but we have no positive evidence that any animal of this class has ever been transmuted into any other kind of creature. These considerations oblige us to restrict our inquiries to the relation of Eozoon to other forms of Foraminiferal life. We may the more excusably take this ground since even Hæckel, in his gastrula theory, has so strenuously maintained the distinctness of the Protozoa from all higher forms of life. Viewed in this way, we find that the proto-foraminifer was the greatest of all in point of magnitude, one of the most complex in regard to structure, compre-

hensive in type, as connecting the groups now recognized as the Nummulines and the Rotalines, and if inferior in anything only in less definiteness of habit of growth, a character in which it is paralleled by the sponges and other groups of higher rank. Thus if Eozoon was really the beginning of Foraminifers, this, like other groups in later times, appeared at first in one of its greatest and best forms, and its geological history consists largely in a gradual deposition from its high place as other and higher types little by little took its place; for degradation as well as elevation, belongs to the plan of nature. Eozoon here brings under our notice another phase of a creative law, which is corroborated by other forms of life in the succeeding periods. It is this. New types do not usually appear in their lowest forms, but in somewhat high if generalized species. The fact that Foraminifera, allied to Eozoon, have continued to exist ever since, introduces us to still another, namely, that though species and individuals die, any large group once introduced is very permanent, and may continue to be represented for the remainder of geological time.

But let us leave for the present the somewhat isolated case of Eozoon, and the few scattered forms of the Huronian and early Cambrian life, and go on further to the Primordial fauna. This is graphically presented to us in the sections at St. David's in South Wales, as described by Hicks. Here we find a nucleus of ancient rocks supposed to be Laurentian, though in mineral character more nearly akin to our Huronian, but which have hitherto afforded no trace of fossils. Resting unconformably on these is a series of partially altered rocks, regarded as Lower Cambrian, and also destitute of organic remains. These have a thickness of almost 1,000 feet, and they are succeeded by 3,000 feet more of similar rocks, still classed as Lower Cambrian, but which have afforded fossils. The lowest bed which contains indications of life is a red shale, perhaps a deep-sea bed, and possibly itself of organic origin, by that strange process of decomposition or dissolution of foraminiferal ooze, described by Dr. Wyville Thomson as occurring in the South Pacific. The species are two *Lingulellæ*, a *Discina* and a *Leperditia*. Supposing these to be all, it is remarkable that we have no Protozoa or Corals or Echinoderms, and that the types of Brachiopods and Crustaceans are of comparatively modern affinities. Passing upward through another 1,000 feet of barren sandstone, we reach a zone in which no less than

five genera of Trilobites are found, along with Pteropods and a sponge. Thus it is that life comes in at the base of the Cambrian in Wales, and it may be regarded as a fair specimen of the facts as they appear in the earlier fossiliferous beds succeeding the Laurentian. Taking the first of these groups of fossils, we may recognize in the *Leperditia* an ostracod Crustacean closely allied to forms still living in the seas and fresh waters. The *Lingulellæ*, whether we regard them as molluscoids, or with our colleague, Professor Morse, as singularly specialized worms, represent a peculiar and distinct type, handed down, through all the vicissitudes of the geological ages, to the present day. Had the Primordial life begun with species altogether inscrutable and unexampled in succeeding ages, this would no doubt have been mysterious; but next to this is the mystery of the oldest forms of life being also among the newest. One great fact shines here with the clearness of noon-day. Whatever the origin of these creatures, they represent families which have endured till now in the struggle for existence without either elevation or degradation. Here again we may formulate another creative law. In every great group there are some forms much more capable of long continuance than others. Lingula among the Brachiopods is a marked instance.

But when, with Hicks, we surmount the mass of barren beds overlying these remains, which from its unfossiliferous character is probably a somewhat rapid deposit of arctic mud, like that which in all geological time has constituted the rough filling of our continental formations, and have suddenly sprung upon us five genera of Trilobites, including the fewest-jointed and most many-jointed, the smallest and the largest of their race, our astonishment must increase, till we recognize the fact that we are now in the presence of another great law of creation, which provides that every new type shall be rapidly extended to the extreme limits of its power of adaptation.

Before considering these laws, however, let us in imagination transfer ourselves back to the Primordial age, and suppose that we have in our hands a living *Plutonia*, recently taken from the sea, flapping vigorously its great tail, and full of life and energy; an animal larger and heavier than the modern king-crab of our shores, furnished with all that complexity of external parts for which the crustaceans are so remarkable, no doubt with instincts and feelings and modes of action as pronounced as those of its

modern allies, and if Woodward's views are correct, on a higher plane of rank than the king-crab itself, inasmuch as it is a composite type connecting Limuli with Isopods. We have obviously here in the appearance of this great crustacean, a repetition of the facts which we met with in Eozoon ; but how vast the interval between them in geological time, and in zoological rank. Standing in the presence of this testimony, I think it is only right to say that we possess no causal solution of the appearance of these early forms of life ; but in tracing them and their successors upward through the succeeding ages, we may hope at least to reach some expressions of the laws of their succession, in possession of which we may return to attack the mystery of their origin.

First, it must strike every observer that there is a great sameness of plan throughout the whole history of marine invertebrate life. If we turn over the pages of an illustrated text-book of geology, or examine the cases or drawers of a collection of fossils, we shall find extending through every succeeding formation, representative forms of crustaceans, mollusks, corals, etc., in such a manner as to indicate that in each successive period there has been a reproduction of the same type with modifications ; and if the series is not continuous, this appears to be due rather to abrupt physical changes ; since sometimes where two formations pass into each other, we find a gradual change in the fossils by the dropping out and introduction of species one by one. Thus in the whole of the great Palæozoic Period, both in its Fauna and Flora, we have a continuity and similarity of a most marked character.

It is evident that there is presented to us in this similarity of the forms of successive faunas and floras, a phenomenon which deserves very careful sifting as to the question of identity or diversity of species. The data for its comprehension must be obtained by careful study of the series of closely allied forms occurring in successive formations, and our great and undisturbed Palæozoic areas in America, as Nicholson has recently pointed out, seem to give special facilities for this, which should be worked, not in the direction of constituting new species for every slightly divergent form, but in striving to group these forms into large specific types. The Rhynchonellæ of the type of *R. plena*, the Orthids of the type of *O. testudinaria*, the Strophomenæ of the types of *S. alternata* and *S. rhomboidalis*, the Atrypæ of the type of *A.*

reticularis, furnish cases in point among the Brachiopods. There is nothing to preclude the supposition that some of these groups are really specific types, with numerous race modifications. My own provisional conclusion, based on the study of Palæozoic plants, is that the general law will be found to be the existence of distinct specific types, independent of each other, but liable in geological time to a great many modifications, which have often been regarded as distinct species.

While this unity of successive faunæ at first sight presents an appearance of hereditary succession, it loses much of this character when we consider the number of new types introduced without apparent predecessors, the necessity that there should be similarity of type in successive faunæ on any hypothesis of a continuous plan; and above all, the fact that the recurrence of representative species or races in large proportion marks times of decadence rather than of expansion in the types to which they belong. To turn to another period, this is very manifest in that singular resemblance which obtains between the modern mammals of South America and Australia, and their immediate fossil predecessors—the phenomenon being here manifestly that of decadence of large and abundant species into a few depauperated representatives. This will be found to be a very general law, elevation being accompanied by the abrupt appearance of new types and decadence by the apparent continuation of old species, or modifications of them.

This resemblance with difference in successive faunas also connects itself very directly with the successive elevations and depressions of our continental plateaus in geological time. Every great Palæozoic limestone, for example, indicates a depression with succeeding elevation. On each elevation marine animals were driven back into the ocean, and on each depression swarmed in over the land, reinforced by new species, either then introduced or derived by migration from other localities. In like manner on every depression, land plants and animals were driven in upon insular areas, and on reëlevation again spread themselves widely. Now I think it will be found to be a law here that periods of expansion were eminently those of introduction of new specific types, and periods of contraction those of extinction, and also of continuance of old types under new varietal forms.

It must also be borne in mind that all the leading types of in-

vertebrate life were early introduced, that change within these was necessarily limited, and that elevation could take place mainly by the introduction of the vertebrate orders. So in plants, Cryptogams early attained their maximum as well as Gymnosperms, and elevation occurred in the introduction of Phænogams, and this not piecemeal, but as we shall see in the sequel, in great force at once.

Another allied fact is the simultaneous appearance of like types of life in one and the same geological period, over widely separated regions of the earth's surface. This strikes us especially in the comparatively simple and homogeneous life-dynasties of the Palæozoic, when for example we find the same types of Silurian Graptolites, Trilobites and Brachiopods appearing simultaneously in Australia, America and Europe. Perhaps in no department is it more impressive than in the introduction in the Devonian and Carboniferous Ages of that grand cryptogamous and gymnospermous flora which ranges from Brazil to Spitzbergen, and from Australia to Scotland, accompanied in all by the same groups of marine invertebrates. Such facts may depend either on that long life of specific types which gives them ample time to spread to all possible habitats, before their extinction, or on some general law whereby the conditions suitable to similar types of life emerge at one time in all parts of the world. Both causes may be influential, as the one does not exclude the other, and there is reason to believe that both are natural facts. Should it be ultimately proved that species allied and representative, but distinct in origin, come into being simultaneously everywhere, we shall arrive at one of the laws of creation, and one probably connected with the gradual change of the physical conditions of the world.

Another general truth, obvious from the facts which have been already collected, is the periodicity of introduction of species. They come in by bursts or flood-tides at particular points of time, while these great life-waves are followed and preceded by times of ebb in which little that is new is being produced. We labor in our investigation of this matter under the disadvantage that the modern period is evidently one of the times of pause in the creative work. Had our time been that of the early Tertiary or early Mesozoic, our views as to the question of origin of species might have been very different. It is a striking fact, and in illustration of this, that since the glacial age no new species of mammal can

be proved to have originated on our continents, while a great number of large and conspicuous forms have disappeared. It is possible that the proximate or secondary causes of the ebb and flow of life production may be in part at least physical, but other and more important efficient causes may be behind these. In any case these undulations in the history of life are in harmony with much that we see in other departments of nature.

It results from the above and the immediately preceding statement, that specific and generic types enter on the stage in great force and gradually taper off toward extinction. They should so appear in the geological diagrams made to illustrate the succession of life. This applies even to those forms of life which come in with fewest species and under the most humble guise. What a remarkable swarming, for example, there must have been of Marsupial Mammals in the early Mesozoic, and in the Coal formation the only known Pulmonates, four in number, belong to as many generic types.

I have already referred to the permanence of species in geological time. I may now place this in connection with the law of rapid origination and more or less continuous transmission of varietal forms. I may, perhaps, best bring this before you in connection with a group of species with which I am very familiar, that which came into our seas at the beginning of the Glacial age and still exists. With regard to their permanence, it can be affirmed that the shells now elevated in Wales to 1,200, and in Canada to 600 feet above the sea, and which lived before the last great revolution of our continents, a period vastly remote as compared with human history, differ in no tittle from their modern successors after thousands or tens of thousands of generations. It can also be affirmed that the more variable species appear under precisely the same varietal forms then as now, though these varieties have changed much in their local distribution. The real import of these statements, which might also be made with regard to other groups, well known to palæontologists, is of so great significance that it can be realized only after we have thought of the vast time and numerous changes through which these humble creatures have survived. I may call in evidence here a familiar New England animal, the common sand clam, *Mya arenaria*, and its relative *Mya truncata*, which now inhabit together all the northern seas; for the Pacific specimens, from Japan and

California, though differently named, are undoubtedly the same. *Mya truncata* appears in Europe in the Coralline Crag, and was followed by *M. arenaria* in the Red Crag. Both shells occur in the Pleistocene of America, and their several varietal forms had already developed themselves in the Crag, and remain the same today; so that these humble mollusks, littoral in their habits, and subjected to a great variety of conditions, have continued perhaps for one or two thousand centuries to construct their shells precisely as at present. Nor are there any indications of a transition between the two species. I might make similar statements with regard to the Astartes, Buccinums and Tellinæ of the drift, and could illustrate them by extensive series of specimens from my own collections.

Another curious illustration is that presented by the Tertiary and modern faunæ of some oceanic islands far separated from the continents. In Madeira and Porto Santo, for example, according to Lyell, we have fifty-six species of land shells in the former, and forty-two in the latter, only twelve being common to the two, though these islands are only thirty miles apart. Now in the Pliocene strata of Madeira and Porto Santo we find thirty-six species in the former, and thirty-five in the latter, of which only eight per cent. are extinct, and yet only eight are common to the two islands. Further there seem to be no transitional forms connecting the species, and of some of them the same varieties existed in the Pliocene as now. The main difference in time is the extinction of some species and the introduction of others without known connecting links, and the fact that some species, plentiful in the Pliocene, are rare now and vice versa. All these shells differ from those of modern Europe, but some of them are allied to Miocene species of that continent. Here we have a case of continued existence of the same forms, and in circumstances which the more we think of them the more do they defy all our existing theories as to specific origins.

Perhaps some of the most remarkable facts in connection with the permanence of varietal forms of species, are those furnished by that magnificent flora which burst in all its majesty on the American continent in the Cretaceous period, and still survives among us even in some of its specific types. I say survives; for we have but a remnant of its forms living, and comparatively little that is new has probably been added since. The confusion which

obtains as to the age of this flora, and the discussions in which Newberry, Heer, Lesquereux and recently Mr. G. M. Dawson, have taken part, obviously arise, as the latter has I think conclusively shown, from the fact that this modern flora was in its earlier times contemporary with Cretaceous animals, and survived the gradual change from the animal life of the Cretaceous down to that of the Eocene and even of the Miocene. In a collection of these plants from what may be termed beds of transition from the Cretaceous to the Tertiary, I find among other modern species two recent ferns most curiously associated. One is the common *Onoclea sensibilis*, found now very widely over North America, and which in so-called Miocene times lived in Europe also. The other is *Davallia tenuifolia* of Eastern Asia—a fern not now even generically represented in North America, but still abundant on the other side of the Pacific. These little ferns are thus probably older than the Rocky Mountains and the Himalayas, and reach back to a time when the Mesozoic Dinosaurs were becoming extinct and the earliest Placental mammals being introduced. Shall we say that these ferns and along with them our two species of American Hazel and many other familiar plants, have propagated themselves unchanged for half a million of years?

Take from the western Mesozoic a contrasting yet illustrative fact. In the Jurassic or Cretaceous rocks of Queen Charlotte's Island, Mr. Richardson, of the Canadian Survey, finds Ammonites and allied cephalopods similar in many respects to those discovered further south by your California survey, and Mr. Whiteaves finds that some of them are apparently not distinct from species described by the Palæontologists of the Geological Survey of British India. On both sides of the Pacific these shells lie entombed in solid rock, and the Pacific rolls between as of yore. Yet these species, genera and even families, are all extinct—why, no man can tell, while land plants that must have come in while the survivors of these cephalopods still lived, reach down to the present. How mysterious is all this, and how strongly does it show the independence in some sense of merely physical agencies on the part of the manifestations of life.

Such facts as those to which I have referred, and many others which want of time prevents me from noticing, are in one respect eminently unsatisfactory, for they show us how difficult must be any attempts to explain the origin and succession of life. For

this reason they are quietly put aside or explained away in most of the current hypotheses on the subject. But we must as men of science face these difficulties, and be content to search for facts and laws even if they should prove fatal to preconceived views.

A group of new laws, however, here breaks upon us. (1) The great vitality and rapid extension and variation of new specific types. (2) The law of spontaneous decay and mortality of species in time. (3) The law of periodicity and of simultaneous appearance of many allied forms. (4) The abrupt entrance and slow decay of groups of species. (5) The extremely long duration of some species in time. (6) The grand march of new forms landwards, and upwards in rank. Such general truths deeply impress us at least with the conclusion that we are tracing, not a fortuitous succession, but the action of power working by law.

I have thus far said nothing of the bearing of the prevalent ideas of descent with modification, on this wonderful procession of life. None of these of course can be expected to take us back to the origin of living beings; but they also fail to explain why so vast numbers of highly organized species struggle into existence simultaneously in one age and disappear in another, why no continuous chain of succession in time can be found gradually blending species into each other, and why in the natural succession of things, degradation under the influence of external conditions and final extinction seem to be laws of organic existence. It is useless here to appeal to the imperfection of the record or to the movements or migrations of species. The record is now in many important parts too complete, and the simultaneousness of the entrance of the faunas and floras too certainly established, and moving species from place to place only evades the difficulty. The truth is that such hypotheses are at present premature, and that we require to have larger collections of facts. Independently of this, however, it appears to me that from a philosophical point of view it is extremely probable that all theories of evolution as at present applied to life, are fundamentally defective in being too partial in their character; and perhaps I cannot better group the remainder of the facts to which I wish to refer than by using them to illustrate this feature of most of our larger attempts at generalization on this subject.

First, then, these hypotheses are too partial, in their tendency to refer numerous and complex phenomena to one cause, or to a

few causes only, when all trustworthy analogy would indicate that they must result from many concurrent forces and determinations of force. We have all no doubt read those ingenious, not to say amusing, speculations in which some entomologists and botanists have indulged with reference to the mutual relations of flowers and haustellate insects. Geologically the facts oblige us to begin with Cryptogamous plants and mandibulate insects, and out of the desire of insects for non-existent honey, and the adaptations of plants to the requirements of non-existent suctorial apparatus, we have to evolve the marvellous complexity of floral form and coloring, and the exquisitely delicate apparatus of the mouths of haustellate insects. Now when it is borne in mind that this theory implies a mental confusion on our part precisely similar to that which in the department of mechanics actuates the seekers for perpetual motion, that we have not the smallest tittle of evidence that the changes required have actually occurred in any one case, and that the thousands of other structures and relations of the plant and the insect have to be worked out by a series of concurrent evolutions so complex and absolutely incalculable in the aggregate, that the cycles and epicycles of the Ptolemaic astronomy were child's play in comparison, we need not wonder that the common sense of mankind revolts against such fancies, and that we are accused of attempting to construct the universe by methods that would baffle Omnipotence itself, because they are simply absurd. In this aspect of them indeed such speculations are necessarily futile, because no mind can grasp all the complexities of even any one case, and it is useless to follow out an imaginary line of development which unexplained facts must contradict at every step. This is also no doubt the reason why all recent attempts at constructing "Phylogenies" are so changeable, and why no two experts can agree about almost any of them.

A second aspect in which such speculations are too partial, is in the unwarranted use which they make of analogy. It is not unusual to find such analogies as that between the embryonic development of the individual animal and the succession of animals in geological time placed on a level with that reasoning from analogy by which geologists apply modern causes to explain geological formations. No claim could be more unfounded. When the geologist studies ancient limestones built up of the remains of corals, and then applies the phenomena of modern coral reefs to explain

their origin, he brings the latter to bear on the former by an analogy which includes not merely the apparent results but the causes at work, and the conditions of their action, and it is on this that the validity of his comparison depends, in so far as it relates to similarity of mode of formation. But when we compare the development of an animal from an embryo cell with the progress of animals in time, though we have a curious analogy as to the steps of the process, the conditions and causes at work are known to be altogether dissimilar, and therefore we have no evidence whatever as to identity of cause, and our reasoning becomes at once the most transparent of fallacies. Farther we have no right here to overlook the fact that the conditions of the embryo are determined by those of a previous adult, and that no sooner does this hereditary potentiality produce a new adult animal, than the terrible external agencies of the physical world, in presence of which all life exists, begin to tell on the organism, and after a struggle of longer or shorter duration it succumbs to death and its substance returns into inorganic nature, a law from which even the longer life of the species does not seem to exempt it. All this is so plain and manifest that it is extraordinary that evolutionists will continue to use such partial and imperfect arguments. Another illustration may be taken from that application of the doctrine of natural selection to explain the introduction of species in geological time, which is so elaborately discussed by Sir C. Lyell in the last edition of his "Principles of Geology." The great geologist evidently leans strongly to the theory, and claims for it the "highest degree of probability," yet he perceives that there is a serious gap in it; since no modern fact has ever proved the origin of a new species by modification. Such a gap, if it existed in those grand analogies by which we explain geological formations through modern causes, would be admitted to be fatal.

A third illustration of the partial character of these hypotheses may be taken from the use made of the theory deduced from modern physical discoveries, that life must be merely a product of the continuous operation of physical laws. The assumption, for it is nothing more, that the phenomena of life are produced merely by some arrangement of physical forces, even if it be admitted to be true, gives only a partial explanation of the possible origin of life. It does not account for the fact that life as a force or combination of forces is set in antagonism to all other forces. It

does not account for the marvellous connection of life with organization. It does not account for the determination and arrangement of forces implied in life. A very simple illustration may make this plain. If the problem to be solved were the origin of the mariner's compass, one might assert that it is wholly a physical arrangement both as to matter and force. Another might assert that it involves mind and intelligence in addition. In some sense both would be right. The properties of magnetic force and of iron or steel are purely physical, and it might even be within the bounds of possibility that somewhere in the universe a mass of natural loadstone may have been so balanced as to swing in harmony with the earth's magnetism. Yet we would surely be regarded as very credulous if we could be induced to believe that the mariner's compass has originated in that way. This argument applies with a thousand fold greater force to the origin of life, which involves even in its simplest forms so many more adjustments of force and so much more complex machinery.

Fourthly, these hypotheses are partial, inasmuch as they fail to account for the vastly varied and correlated interdependencies of natural things and forces, and for the unity of plan which pervades the whole. These can be explained only by taking into the account another element from without. Even when it professes to admit the existence of a God, the evolutionist reasoning of our day contents itself altogether with the physical or visible universe, and leaves entirely out of sight the power of the unseen and spiritual, as if this were something with which science has nothing to do, but which belongs only to imagination or sentiment. So much has this been the case, that when recently a few physicists and naturalists have turned to this aspect of the case, they have seemed to be teaching new and startling truths, though only reviving some of the oldest and most permanent ideas of our race. From the dawn of human thought, it has been the conclusion alike of philosophers, theologians and the common sense of mankind, that the seen can be explained only by reference to the unseen, and that any merely physical theory of the world is necessarily partial. This, too, is the position of our sacred Scriptures, and is broadly stated in their opening verse, and indeed it lies alike at the basis of all true religion and all sound philosophy, for it must necessarily be that "the things that are seen are temporal, the things that are unseen, eternal." With reference to the primal

aggregation of energy in the visible universe, with reference to the introduction of life, with reference to the soul of man, with reference to the heavenly gifts of genius and prophecy, with reference to the introduction of the Saviour himself into the world, and with reference to the spiritual gifts and graces of God's people, all these spring not from sporadic acts of intervention, but from the continuous action of God and the unseen world, and this we must never forget is the true ideal of creation in Scripture and in sound theology. Only in such exceptional and little influential philosophies as that of Democritus, and in the speculations of a few men carried off their balance by the brilliant physical discoveries of our age, has this necessarily partial and imperfect view been adopted. Never indeed was its imperfection more clear than in the light of modern science.

Geology, by tracing back all present things to their origin, was the first science to establish on a basis of observed facts the necessity of a beginning and end of the world. But even physical science now teaches us that the visible universe is a vast machine for the dissipation of energy; that the processes going on in it must have had a beginning in time, and that all things tend to a final and helpless equilibrium. This necessity implies an unseen power, an invisible universe, in which the visible universe must have originated and to which its energy is ever returning. The hiatus between the seen and the unseen may be bridged over by the conceptions of atomic vortices of force, and by the universal and continuous ether; but whether or not, it has become clear that the conception of the unseen as existing has become necessary to our belief in the possible existence of the physical universe itself, even without taking life into the account.

It is in the domain of life, however, that this necessity becomes most apparent; and it is in the plant that we first clearly perceive a visible testimony to that unseen which is the counterpart of the seen. Life in the plant opposes the outward rush of force in our system, arrests a part of it on its way, fixes it as potential energy, and thus, forming a mere eddy, so to speak, in the process of dissipation of energy, it accumulates that on which animal life and man himself may subsist, and assert for a time supremacy over the seen and temporal on behalf of the unseen and eternal. I say, for a time, because life is, in the visible universe, as at present constituted, but a temporary exception, introduced from that un-

seen world where it is no longer the exception but the eternal rule. In a still higher sense then than that in which matter and force testify to a Creator, organization and life, whether in the plant, the animal or man, bear the same testimony, and exist as outposts put forth in the succession of ages from that higher heaven that surrounds the visible universe. In them, too, Almighty power is no doubt conditioned or limited by law, yet they bear more distinctly upon them the impress of their Maker, and, while all explanations of the physical universe which refuse to recognize its spiritual and unseen origin, must necessarily be partial and in the end incomprehensible, this destiny falls more quickly and surely on the attempt to account for life and its succession on merely materialistic principles.

Here, again, however I must remind you that creation, as maintained against such materialistic evolution, whether by theology, philosophy or Holy Scripture, is necessarily a continuous, nay, an eternal influence, not an intervention of disconnected acts. It is the true continuity, which includes and binds together all other continuity.

It is here that natural science meets with theology, not as an antagonist, but as a friend and ally in its time of greatest need; and I must here record my belief that neither men of science nor theologians have a right to separate what God in Holy Scripture has joined together, or to build up a wall between nature and religion, and write upon it "no thoroughfare." The science that does this must be impotent to explain nature and without hold on the higher sentiments of man. The theology that does this must sink into mere superstition.

In conclusion, can we formulate a few of the general laws, or perhaps I had better call them the general conclusions respecting life, in which all Palæontologists may agree. Perhaps it is not possible to do this at present satisfactorily, but the attempt may do no harm. We may, then, I think, make the following affirmations:—

1. The existence of life and organization on the earth is not eternal, or even coeval with the beginning of the physical universe, but may possibly date from Laurentian or immediately pre-Laurentian times.

2. The introduction of new species of animals and plants has been a continuous process, not necessarily in the sense of deriva-

tion of one species from another, but in the higher sense of the continued operation of the cause or causes which introduced life at first. This, as already stated, I take to be the true theological or Scriptural as well as scientific idea of what we ordinarily and somewhat loosely term creation.

3. Though thus continuous, the process has not been uniform; but periods of rapid production of species have alternated with others in which many disappeared and few were introduced. This may have been an effect of physical cycles reacting on the progress of life.

4. Species like individuals have greater energy and vitality in their younger stages, and rapidly assume all their varietal forms, and extend themselves as widely as external circumstances will permit. Like individuals also, they have their periods of old age and decay, though the life of some species has been of enormous duration in comparison with that of others; the difference appearing to be connected with degrees of adaptation to different conditions of life.

5. Many allied species, constituting groups of animals and plants, have made their appearance at once in various parts of the earth, and these groups have obeyed the same laws with the individual and the species in culminating rapidly, and then slowly diminishing, though a large group once introduced has rarely disappeared altogether.

6. Groups of species, as genera and orders, do not usually begin with their highest or lowest forms, but with intermediate and generalized types, and they show a capacity for both elevation and degradation in their subsequent history.

7. The history of life presents a progress from the lower to the higher, and from the simpler to the more complex, and from the more generalized to the more specialized. In this progress new types are introduced and take the place of the older ones, which sink to a relatively subordinate place and become thus degraded. But the physical and organic changes have been so correlated and adjusted that life has not only always maintained its existence, but has been enabled to assume more complex forms, and that older forms have been made to prepare the way for newer, so that there has been on the whole a steady elevation culminating in man himself. Elevation and specialization have, however, been secured at the expense of vital energy and range of adaptation,

until the new element of a rational and inventive nature was introduced in the case of man.

9. In regard to the larger and more distinct types, we cannot find evidence that they have, in their introduction, been preceded by similar forms connecting them with previous groups; but there is reason to believe that many supposed representative species in successive formations are really only races or varieties.

10. In so far as we can trace their history, specific types are permanent in their characters from their introduction to their extinction, and their earlier varietal forms are similar to their later ones.

11. Palæontology furnishes no direct evidence, perhaps never can furnish any, as to the actual transformation of one species into another, or as to the actual circumstances of creation of a species, but the drift of its testimony is to show that species come in *per saltum*, rather than by any slow and gradual process.

12. The origin and history of life cannot, any more than the origin and determination of matter and force, be explained on purely material grounds, but involve the consideration of power referable to the unseen and spiritual world.

Different minds may state these principles in different ways, but I believe that in so far as palæontology is concerned, in substance they must hold good, at least as steps to higher truths. And now allow me to say that we should be thankful that it is given to us to deal with so great questions, and that in doing so, deep humility, earnest seeking for truth, patient collection of all facts, self-denying abstinence from hasty generalizations, forbearance and generous estimation with regard to our fellow-laborers, and reliance on that divine Spirit which has breathed into us our intelligent life, and is the source of all true wisdom, are the qualities which best become us. While thanking you for the honor which you have done me in inviting me to deliver this address, and in conveying to you the kindly regards and good wishes of all your fellow-workers in the Canadian Dominion, allow me to express the fervent hope that we all may be one in our patient and earnest search for the truth.